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Atlas of EEG, Seizure Semiology, and Management

Karl E. Misulis

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Introduction to EEG

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Author(s): Karl E Misulis
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Electroencephalography (EEG) is an invaluable tool for evaluating patients for suspected seizures and encephalopathy. While the study of EEG itself can be exhaustive, as clinicians, we need to keep EEG in its supportive role. As such, the study of EEG must necessarily be performed on a solid foundation of clinical neurology and basic neuroscience.

Seizures and Epilepsy

Definitions

This is not a comprehensive glossary, as found elsewhere, but rather a summary of the important terms for classification and definition of seizures (see Table 1-1).

Table 1-1 Select Definitions

Term	***Definition***
Seizure	Sudden attack that is usually due to abnormal rhythmic discharge of neurons.
Epilepsy	Recurrent episodes of seizure activity typically associated with abnormal EEG rhythms.
Semiology	Study of signs of seizures.
Prodrome	Change in mood or cognition prior to a seizure, but which is not part of the seizure discharge.
Aura	Subjective sensation that precedes a seizure.
Ictal discharge	EEG discharge that is associated with a seizure.
Interictal discharge	EEG discharge that is seen in patients with seizures, yet the discharge is not itself a seizure.
Postictal period	Episode of altered consciousness or cognition following a seizure.
A complete glossary is provided in the Appendix.	

The most critical distinction is between *seizure* and *epilepsy*. A seizure is a transient event that includes symptoms and/or signs of abnormal excessive hypersynchronous activity in the brain (Fisher et al., 2005), whereas epilepsy is a disorder in which the patient has recurrent unprovoked seizures. All patients with epilepsy have seizures, whereas not all patients who have had a seizure have epilepsy. Recurrent seizures due to severe hyponatremia do not quality as epilepsy, since severe hyponatremia is known to provoke seizures. The traditional definition of epilepsy is that it takes at least two unprovoked seizures for the definition. A recent proposal suggested that one unprovoked seizure is sufficient if there is also evidence of enduring seizure tendency such as epileptiform activity on the EEG (Fisher et al., 2005). This proposal has been controversial and the authors favor the definition that requires at least two seizures.

Classifications

Before discussing the types of seizures, an introduction to seizure symptoms and signs is appropriate.

Symptoms and Signs

- *Prodrome* is an abnormal sensation preceding the seizure in some patients, not associated with epileptiform discharge.
- *Aura* is a subjective sensation that can immediately precede a seizure. This represents the initial portion of the epileptiform discharge.
- *Clonic activity* is episodic muscle contraction associated with a seizure.
- *Tonic activity* is increased muscle tone during a seizure, resulting in stiffening.
- *Automatism* is a stereotyped movement that occurs as part of a seizure, such as lip smacking.
- *Postictal period* is an episode of altered consciousness or cognition following a seizure.

Classification of Seizures and Epilepsies

The 1981 international classification is still the most commonly used seizure classification. It based on both EEG and clinical features of seizures (Commission on Classification and Terminology, 1981). Classification of seizures (Table 1-2) has two broad categories based on the onset being partial or generalized. *Partial-onset seizures* begin with a discharge in a focus, although they then can spread to other parts of the brain. Seizures that are generalized at onset, termed *primary generalized*, start bilaterally in the brain. Generalized seizures may have some asymmetry, but that usually switches from side to side.

Table 1-2 Classification of Seizures

Major Classification	***Selected Seizure Types***
Generalized	*Absence*: Staring spells with decreased response, often associated with subtle automatisms, lasting a few seconds, and with no postictal period.
	Generalized tonic-clonic: Sudden loss of consciousness, tonic stiffening followed by clonic movements of the body and/or extremities. Postictal period subsequently.
	Atonic: Sudden loss of tone which can be subtle (such as dropping of head), or widespread resulting in fall.
	Myoclonic: Brief seizures, lasting a fraction of a second. May be very focal and subtle or widespread and severe.
	Tonic: Sudden loss of consciousness with tonic posturing. Usually in neurologically impaired individuals.
Partial	*Simple:* Focal neurologic symptoms which can vary widely depending on location of origin, but without disturbance of consciousness.
	Complex: Focal neurologic symptoms including disturbance of consciousness.
	Secondarily generalized partial onset: Partial seizure of either simple or complex type which then spreads to become a generalized seizure.

Partial seizures are further subdivided into simple partial and complex partial. *Simple partial seizures* do not disturb consciousness, whereas *complex partial seizures* disturb consciousness. Complex partial seizures were previously termed *psychomotor* because of the cognitive disturbance. Partial-onset seizures can spread to involve most of the brain, and this is termed *secondary generalized seizure*.

Other classification schemes have been suggested that could be helpful in specific circumstances. One proposed seizure classification that has been used in the presurgical evaluation of epilepsy is purely semiological, based solely on observed clinical features. This classification includes somatotopic distribution of the seizure manifestations and evolution of these manifestations over the course of the seizure (Lüders et al., 1998). This classification will not be used in this book.

The International League Against Epilepsy (ILAE) has classified epilepsy syndromes into types summarized in Table 1-3. The classification of epilepsies still has two major subdivisions, localization-related (partial or focal being accepted synonyms), and generalized. Most patients will have only partial-onset seizures or only generalized onset seizures, and be classified into one of these two categories. There is a small group of patients with epilepsy who have both partial-onset and generalized onset seizures. They are classified in a third category of epilepsies and syndromes undetermined as to whether they are focal or generalized. Also classified into that category are subjects who do not have enough evidence for the type of seizure onset.

Table 1-3 Classification of Epilepsies

Classification	***Types***
Localization related (focal or partial)	*Idiopathic (pure epilepsy not related to an underlying cause)*
	Symptomatic (known etiology)
	Cryptogenic (presumed to be symptomatic but cause is unknown)
Generalized	*Idiopathic*
	Cryptogenic
	Symptomatic – can be nonspecific etiology or a specific etiology.
Undetermined as to whether focal or generalized	*With both generalized and focal seizures.*
	Without unequivocal generalized or focal features.
Special syndromes	*Include situation-related seizures – febrile convulsions, isolated seizures or isolated status epilepticus, seizures only when there is an acute metabolic or toxic event.*

Adapted from the Commission on Classification and Terminology of the International League Against Epilepsy, 1989. Proposal for revised classification of epilepsies and epileptic syndromes. *Epilepsia* 30, 389–399.

The classifications of seizures and epilepsies are evolving. The most recent revision of the seizure classification proposed by the International League Against Epilepsy has maintained the major division of seizures based on onset being generalized or partial, but has recommended replacing the term "partial" with "focal". Focal seizures were acknowledged to originate within networks limited to one hemisphere, meaning that they could be widely distributed in one hemisphere and possibly originating in subcortical structures. Generalized seizures were defined as "originating at some point within, and rapidly engaging, bilaterally distributed networks," which do not necessarily include the entire cortex (Berg et al., 2010a,b).

Not included in this classification are non-epileptic seizures previously termed *pseudoseizures*. A major task of the clinician and EEG-reader is the differentiation of epilepsy from non-epileptic events such as psychogenic non-epileptic seizures, cardiac arrhythmia, vasovagal syncope, orthostatic hypotension, transient ischemic attacks (TIA), and other conditions. This is discussed in depth in Chapter 6.

Semiology

Semiology is a non-medical term meaning the study of signs and symbols, which in our context means the symptoms and signs of seizures. The semiology of seizures of different localizations is discussed in detail in Chapter 5. A brief summary is provided in Tables 1-4 and 1-5.

Table 1-4 Semiology of Generalized Seizures

Seizure Type	***Features***
Absence	Staring spells.Automatisms that may be simple.Loss of awareness.Brief, usually less than 15 seconds.Occasional motor manifestations.
Tonic-clonic	Sudden loss of consciousness.Generalized tonic and/or clonic movements.
Myoclonic	Brief jerks that are variable in intensity, from small twitch to a massive jerk.Usually bilateral but may be unilateral.Often occur in clusters.No disturbance of consciousness.
Atypical absence	Loss of awareness.Slower recovery than with absence.Differentiated from absence mainly by EEG appearance.

Table 1-5 Semiology of Partial Seizures

Seizure Type	***Features***
Temporal	90% have aura.Most common aura is epigastric.Motor arrest, or Motionless staring, or Automatisms that may be oro-alimentary or extremity.
Frontal	Aura is uncommon. May be epigastric sensation. Focal clonic or tonic-clonic seizures.
Parietal	Sensory aura, which may have march. Can also have vertigo or focal weakness. Staring, or Tonic posturing, or Focal clonic activity, or Head and eye deviation, or Immobility.
Occipital	Elementary visual aura, or Visual hallucination. Blinking, and/or Ictal blindness.

Semiology in these tables refers to primary generalized seizures (Table 1-4) and partial-onset seizures without generalization (Table 1-5). Partial-onset seizures with secondary generalization are more complex and are discussed in Chapter 5.

Role of EEG in Diagnosis and Management

Routine EEG

Routine EEG is commonly performed in patients with episodic disorders in whom the differential diagnosis includes seizures and in selected patients with encephalopathy.



Valid indications for EEG include:

- Seizure or possible seizure;
- Well-controlled epilepsy to evaluate risk of recurrence upon withdrawal of treatment
- Syncope without definite cardiac or vascular cause;
- Loss of consciousness;
- Dementia when prion or virus is considered as an etiology;
- Encephalopathy without definite explanation;
- Coma.

Not valid indications for EEG include:

- Headache;
- Chronic behavioral disorder;
- Dizziness or vertigo;

While the majority of patients who have EEGs performed have suspected seizures, we will occasionally see patients in whom the documented reason for referral is dizziness or headache. Unless there is more to the story, these are inappropriate reasons for performing an EEG.

On the other hand, some epileptic syndromes are likely under-diagnosed. Non-convulsive seizures, including non-convulsive status epilepticus, may be incorrectly assumed to be metabolic encephalopathy, drug intoxication, or critical illness encephalopathy. Similarly, episodic focal deficits may be assumed to be transient ischemic attacks (TIA) yet are ultimately diagnosed as partial seizures. In these patients a positive motor component may be subtle or the history merely incomplete.

EEG-Video Monitoring

EEG-video monitoring refers to prolonged EEG with simultaneous video recording, intended to capture clinical events. It allows the correlation of brain electrical activity with clinical manifestations. *It is performed most commonly for the following indications:*

- Differentiation of epileptic seizures from non-epileptic seizures;
- Classification of seizure type to assist treatment.
- Localization of the epileptogenic zone in the presurgical evaluation of patients with drug-resistant seizures;

Less common indications for video EEG include:

- Quantification of seizures, particularly when seizures are very frequent and often missed by the patient.
- Quantification of response to treatment.
- Studying seizure precipitants particularly in reflex epilepsy.
- Documentation of ictal and interictal discharges during circadian rhythms.
- Evaluating the clinical correlate of EEG discharges which are unclear as to whether they are ictal or interictal.





